Development of Catalytic Membranes for Direct Synthesis of Hydrogen Peroxide

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Motivation

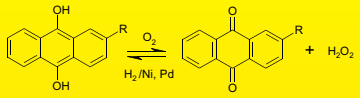
- Hydrogen Peroxide may be produced by direct reaction of H_2 and O_2 on a heterogeneous catalyst.

$$O_2 \quad H_2 \quad H_2O_2$$

- Reaction is thermodynamically favourable.
- Low temperature and high pressure have positive effect on yield.
- Tubular ceramic membrane (TCM) may be employed as a new type of heterogeneous catalyst. They are composed of support layer, fine porous layer and active noble metal e.g. Pd. They offer following advantages.
- No direct contact between H_2 and O_2 thus safer operation.
- Reaction rate is not impeded by the solubility of H_2 in liquid medium.
- Easy scale-up
- Efficient gas liquid contact on the solid surface of a TCM.

Conventional Process

- Hydrogen peroxide is mainly manufactured via Anthraquinone process:

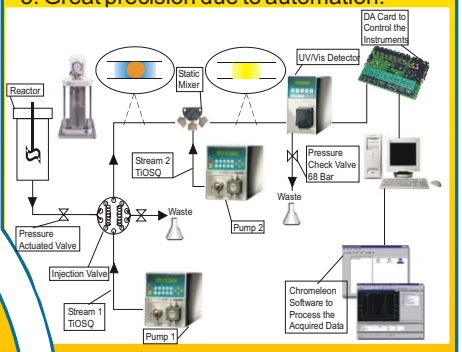


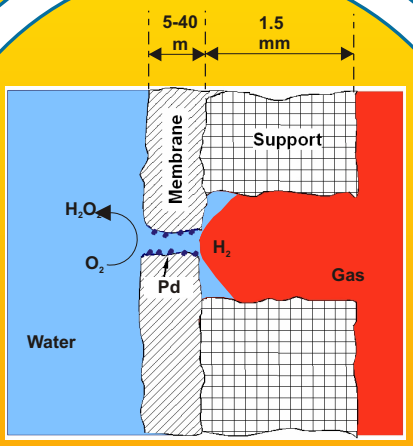
- Large investment cost.
- Only suitable for large production units.
- High cost of redox couple and solvent system.
- Number of side reactions in the system.
- Energy demanding purification and separation.

FIA

- A method to automatically determine the concentration of hydrogen peroxide was required.
- Flow Injection Analysis (FIA) was chosen because:

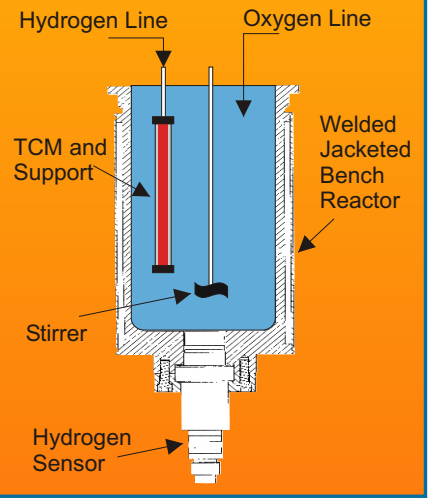
1. Easy to understand and implement.
2. Easily assembled and inexpensive.
3. Provides a simple means of automating manual wet determinations.
4. Smaller sample and reagent consumption.
5. Great precision due to automation.





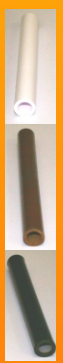
Experiment Setup

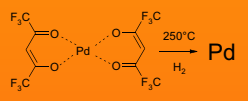
- Working pressure up to 10 bar with glass jacket and up to 70 bar with stainless steel jacket.
- The temperature is controlled by a cryostat.
- A line leaves the reactor to the FIA for analysis.



Membrane Preparation

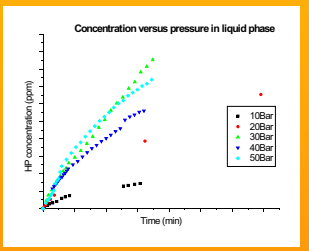
- Starting material: Al_2O_3 support with a 100 nm -Al_2O_3 membrane layer.
- The membrane is coated with polyfurfurylalcohol (picture shows un-carbonized membrane)
- Membrane is deposited with Pd by CVD using palladium(II)-hexafluro-acetylacetonate.



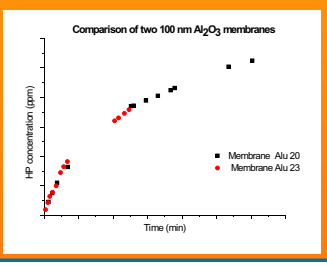


Results

- The graph shows how increasing the pressure within the reactor increases the amount and rate of hydrogen peroxide produced.



- The graph shows that different membranes have similar properties, as the plots follow the same profile, meaning that membrane production is reproducible.



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